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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/649,099	08/26/2003	Woody K. Sattayapiwat Tang	M-12977 US	4957

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EXAMINER

DAHIMENE, MAHMOUD

ART UNIT	PAPER NUMBER
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1765

DATE MAILED: 05/18/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/649,099

Applicant(s)

TANG ET AL.

Examiner

Mahmoud Dahimene

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 03/03/06.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-18 and 24-40 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1,4-12,16-18,24-29,31-35 and 38 is/are rejected.
- 7) ☒ Claim(s) 2,3,13-15,30,36,37,39 and 40 is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. _____.
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. _____ |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| Paper No(s)/Mail Date. _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Claim Rejections - 35 USC § 102/103

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

1. Claims 1, 3, 7, 8, 9, 16, 31-35, 38 are rejected under 35 U.S.C. 102(b) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as obvious over Chen et al. (US 5,661,083).
3. Claims 1, 3, 7, 8, 9, 16, 31-35, 38 are rejected under 35 U.S.C. 102(b) as being anticipated by Chen et al. (US 5,661,083).

Regarding claims 1, 31-35, the reference of Chen describes a method for via formation with reduced contact resistance wherein a structure is shown (figure 2B) to have a photoresist layer (210) on top an oxide layer (208)(which reads on applicant's

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limitation of an oxide based layer positioned on top (with an interface) of an ARC layer (206). Chen teaches "also formed during the oxide etching process is a coating of polymeric debris which is deposited on the floor of the via" (column 4, line 18). For example, where carbon tetrafluoride (CF_4) is used as the processing gas, SiO_2 is used as the oxide layer and (TiW) or (TiN) is used as the ARC, the polymeric debris formed in the via comprises polytetrafluoroethylene (C_2F_2) in addition to atoms of oxygen, silicon, titanium, and aluminum (column 1, lines 50-58) (which reads on the applicant's limitation of residues containing oxides and fluorides of titanium). Clearly Chen teaches residues will contain materials from layers that have been etched or contacted by the etching plasma in addition to byproducts of the gases used in the plasma for etching the layers. Chen further discloses A portion of the oxide layer is then removed to expose the underlying etch stop layer (ARC). A portion of the etch stop layer is then removed using a reactive ion etch-downstream microwave ash system (column 2, line 32), the reactive ion etch is performed under a nitrogen/hydrogen (N_2/H_2) atmosphere. In a more specific embodiment, the atmosphere further includes carbon tetrafluoride (CF_4) (which reads on applicant's limitation of a first agent which will react with the TiN ARC layer to produce volatile byproduct (column 2, line 45).

It is noted that Chen is silent about the formation of residue nodules having a base anchor portion and top portion, however, it would appear that the oxide etch process of Chen would inherently result in exposure of nodules having a base anchor portion and top portion including nodule of different sizes because Chen discloses the

same structure as the one claimed by the applicant of an oxide layer overlying a metal containing ARC layer and wherein the oxide has been patterned to expose the arc layer. The method of Chen removes those nodules by exposure to the N₂/H₂/CF₄ plasma, this chemistry certainly reacts with a first metal element of the metal containing ARC layer (Ti) to produce volatile products, and the plasma molecules are sufficiently small in size to operatively enter reaction zones of the anchor portions of the nodules.

In addition, applicant's claimed formation of nodules with base anchor portion reacting with the chemically reactive agent would obviously be produced upon practicing the process of Chen et al. (US 5,661,083).

As to claim 3, Chen discloses TiN or TiW for the ARC layer, and Ti is in the residue (column 1, lines 50-58).

As to claim 7, both references of Chen (column 2, line 45) further include one reactive agents (H₂) in the plasma which can reduce oxidized metal to produce volatile material when reacting with CF₄.

As to claims 8, 9, the reference of Chen (column 2, line 45) further include a chemically non reacting agent in the cleaning plasma such as N₂.

Claim Rejections - 35 USC § 103

4. Claims 16, 17, 18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chen et al. (US 5,661,083).

Regarding claim 16, the reference of Chen discloses a plasma power in the range between 100-300 Watts (column 2, line 53). The disclosure of an endpoint of 300 Watts overlaps applicant's claimed range. Overlapping ranges are held to be obvious.

Regarding claim 17, Chen discloses a reactive ion etch at 13.65 MHz was performed at a power of 100 Watts (column 6, line 23) (which reads on a pedestal bias power) which is within the range of 80 to 200 Watts claimed by the applicant in claim 17. Overlapping ranges are held to be obvious.

Regarding claim 18, It is noted that the reference of Chen does not disclose applicant's specific cleaning time. However, cleaning time is related to the degree of removal. As a result, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select any amount of time necessary to achieve the desired level of removal, including the specific times claimed by the applicant, because the degree of cleaning is related to the amount of process time. Applicant has not shown anything unexpected with respect to the cleaning time.

Claim Rejections - 35 USC § 103

5. Claims 10-12, 27-28 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chen et al. (US 5,661,083) in view of S. Wolf et al. (Silicon Processing for the VLSI Era, Volume 1- Process Technology, Lattice Press, 1986, pages 546-547).

Regarding claims 10-12, 27-28 it is noted that the reference of Chen fails to disclose applicant's specially claimed flow rates and flow ratios.

The reference of Wolf et al. teaches that gas flow rates have a direct effect on the processed surface (pages 546-547).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select any flow rate or flow ratio that would accomplish the production of an effective plasma including the flow rates and flow ratios claimed by the applicant in claims 10-12 because Wolf teaches it is conventional to select the proper gas flows in a plasma in order to achieve the desired results of a given processed surface. One of ordinary skill in the art would have been motivated to adjust the proper flow rates to the plasma in order to obtain the desired result.

Claim Rejections - 35 USC § 102

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

6. Claims 24, 25, 26 are rejected under 35 U.S.C. 102(e) as being anticipated by Chiu et al. (US 20040157444).

Regarding claims 24, 25, Chiu discloses a photoresist intensive patterning and processing wherein a layer (12) of Anti Reflective Coating TiN (ARC) (page 3, paragraph 56) is first deposited over the surface of a silicon based or oxide based semiconductor surface (figure 2), a dual hardmask is deposited over the surface of the layer of ARC, in one example, the dual hardmask comprises (an oxygen-poor) silicon oxynitride interfacial layer (14) deposited between the ARC layer (page 3, paragraph 59) and a silicon oxide layer (16) (page 4, paragraph 60) or PE-TEOS (page 3, paragraph 57). A layer of soft mask material (18) is next coated over the surface of the dual hardmask layer, the layer of soft mask material is exposed, creating a soft mask material mask. Chiu further discusses a residue free cleaning procedure (page 4, paragraph 65).

Chiu teaches [page 3, Paragraph 0051] The blanket layer 12 may be formed from any of the Anti Reflective Coating materials that are common in the art of microelectronic fabrication. [page 3, Paragraph 0053] Anti-reflective coatings (ARC's) have been developed to minimize the adverse impact due to reflectance from these reflective materials. In many instances, these ARC's are conductive materials which are deposited as a blanket layer on top of metal and simultaneously patterned with the metal to form interconnects. [0054] Some dielectric ARC's, such as silicon rich silicon nitride or aluminum nitride, are most suitable for deep ultraviolet (DUV) radiation. Since the reference of Chiu teaches the same method using the same materials/layers as the

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instant claimed method, under the principle of inherency, Chiu's method would have reduced formation of micromasking residues between a metal containing ARC and the oxide-based hardmask layer.

As to claim 26, Chiu describes Layer 14 of Silicon Oxynitride typically has as formula $\text{SiO}_{\text{sub.x}}\text{N}_{\text{sub.y}}(\text{H}_{\text{sub.z}})$. Silicon Oxynitrides are formed by creating $\text{SiH}_{\text{sub.4}}$ with $\text{N}_{\text{sub.2}}\text{O}$ and $\text{NH}_{\text{sub.3}}$. In order to form a non-conformal layer of SiON, a practical application uses $\text{SiO}_{\text{sub.x}}\text{N}_{\text{sub.y}}$ deposited by PECVD with a gas flow between about 1700 and 2300 sccm of He, a gas flow of between about 80 and 120 sccm of $\text{N}_{\text{sub.2}}\text{O}$, a gas flow of between about 40 and 200 sccm of $\text{SiH}_{\text{sub.4}}$, at a temperature of between about 380 and 480 degrees C. and at a pressure between about 5 and 8 Torr. A typical carrier gas for the formation of a layer of $\text{SiO}_{\text{sub.x}}\text{N}_{\text{sub.y}}$ is $\text{N}_{\text{sub.2}}$ or He (page 3, paragraph 0059). Chiu clearly teaches silicon oxynitride films with specified x and y can be formed.

Chiu discloses an Oxide/Silicon ratio of 1 which is substantially less than 2.

Claim Rejections - 35 USC § 103

7. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

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5. Claims 5 and 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chen et al. (US 5,661,083) in view of Tang et al. (US 6,156,485).

The method of Chen as described above does disclose an oxide layer, but is silent about a specific oxide namely a PE-TEOS oxide.

Tang describes a metal etch method where a PE-oxide (140) or PE-TEOS (column 3, line 67) is used on top of a TiN ARC layer (130) (figure 3A).

Therefor it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the method of Chen by including a PE-TEOS hard mask on top of a TiN ARC layer for a metal etch process because Tang teaches it is conventional to use those materials when etching an underlying metal layer, and the method of Chen can be used for a hardmask open step using the same process steps. One of ordinary skill in the art would have been motivated use Chen's method for hard mask open in order to obtain a residue free open region under the hardmask.

Allowable Subject Matter

8. Claims 2, 3, 13-15, 30, 36, 37, 39, 40 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

The following is a statement of reasons for the indication of allowable subject matter:

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Regarding claims 2, 3, 13, 30, 36, 37, the closest prior art of record of Chen et al. (US 5,661,083) does not disclose or suggest employing HCl, Cl₂ or BCl₃ as a chemically reactive agent with Argon as a non-reactive agent in a plasma for reducing micromasking residues remaining within an exposed interface of an oxide hardmask and metal containing ARC layer, and with the rest of the limitations of claims 1 or 35.

Regarding claims 14-15, the closest prior art of record of Chen et al. (US 5,661,083) does not disclose or suggest employing a plasma in a pressure range from 2 mTorr to 15 mTorr for reducing micromasking residues remaining within an exposed interface of an oxide hardmask and metal containing ARC layer, and with the rest of the limitations of claims 1.

Regarding claims 39 and 40, the closest prior art of record of Chen et al. (US 5,661,083) does not disclose or suggest employing a plasma for removing residues using a chlorine-based dry etch of a metal-containing anti-reflection coating layer (ARC layer) that directly underlies the hardmask, and with the rest of the limitations of claim 38.

7. Claims 2, 3, 13-15, 30, 36, 37, 39, 40 would be allowable if rewritten to overcome the rejection(s), set forth in this office action and to include all of the limitations of the base claim and any intervening claims.

Response to Arguments/Remarks

9. Applicant's arguments, see applicant's remarks, filed 03/03/2006, with respect to rejection of claims 1-18 and 26-30 under 35 USC § 112 have been fully considered and are persuasive. The rejection of claims 1-18 and 26-30 under 35 USC § 112 has been withdrawn.

10. Rejection of claims 24-26 over Chiu et al. under 35 USC § 102(e) is maintained. Applicant's arguments regarding the rejection of claim 24-26 are not persuasive since the reference of Chiu discloses an embodiment where a metal containing ARC layer in the form of TiN, it is considered to meet applicant's limitation. The disclosure of the reference of Chiu is not limited to the preferred embodiment. Since a metal containing ARC layer (TiN) is specifically disclosed, it meets the limitations of applicant's claim 24.

11. Applicant's arguments see applicant's remarks, filed 03/03/2006, with respect to the rejection(s) of claim(s) 1-18, 25-30 over Xiaobing et al. (US 5,387,556) have been fully considered and are persuasive in view of the amendment to the claims referring to the oxide layer and the ARC layer are made adjacent to each other, namely the oxide layer and ARC layers disclosed by Xiaobing et al. are not adjacent, and therefore the stack layer disclosed does no longer read on the applicant's amended claims. Therefore, the rejection has been withdrawn. However, upon further consideration, a

new ground(s) of rejection is made in view of Chen et al. (US 5,661,083), Chiu et al. (US 20040157444) and Tang et al. (US 6156485).

Conclusion

12. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Mahmoud Dahimene whose telephone number is (571) 272-2410. The examiner can normally be reached on week days from 8:00 AM. to 5:00 PM..

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine Norton can be reached on (571) 272-1465. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Mahmoud Dahmane
MD.

NADINE NORTON
ART UNIT 1765
SUPERVISORY PATENT EXAMINER

NL